2: Jochelson E-5 (1884-1902) 1933 Yakut

114 Okhotsk Sea over the Stanovoi Ridge. I ascended the Omolon River about 150 miles from its mouth in 1897 and crossed it in its upper course in 1902 en route from the Okhotsk Sea.

Although my chief objectives were anthropological, I endeavored to obtain geographical and topographical data, particularly in regions not previously visited. With this end in view I always carried the necessary instruments, compasses, sling thermometers, aneroid barometers, boiling point thermometers, and others, and kept systematic diaries.

The Permanent Frozen Soil

● 134 The territory of the Yakut lies within the province in which is distributed the so-called "permanent frozen soil," "fossil ice," "ground ice" or better, "underground ice." This factor which influences the climate and consequently the population of the country merits some consideration. The vast area occupied by the underground ice in northern Asia equals about 7,000,000 square versts, or 3,076,000 square miles, or only a little less than the area of Europe. Another peculiarity of the wide distribution of the underground ice in Asia is its extension far to the south. The existence of underground ice in polar regions, where relatively little heat is radiated from the sun is understandable, but when we observe that in some places this underground ice is found as far south as the latitudes of Kief, Paris, or Vienna, the question becomes complicated.

There are several theories of the origin of underground ice. First, the frost cracks the surface, the snowdrifts and the frozen soil are compressed by the cold and cracked; the melted snow penetrates these crevasses, during the spring and summer expanding them vertically as well as horizontally, depending, however, on the composition of the ground. There, because of the low temperature of the soil, it freezes, forming ice veins, or beds. Especially when they are shallow, the underground ice beds increase the humidity of the surface soil and lead to the formation of morasses and the development of swamp vegetation, particularly turf-mosses. Such soil, even omitting from consideration its geographic position and climatic condition, produces only a few species of vegetation and the arboreal flora is usually reduced to two varieties: the Siberian larch (*Larix sibirica*), and the birch (*Betula alba* or *Betula nana*). Even these appear only as rugged trunks or crooked stunted bushes, the roots of which spread on the surface and do not penetrate deeply into the soil.

No one has investigated the influence of the frozen soil on the fauna. But, as far as we know, many animals adjust themselves to these condi-

2: Jochelson E-5 (1884-1902) 1933 Yakut

tions, not only those living on the surface of the earth or in trees, like the squirrel, the flying-squirrel (*Pteromys*), polar hare, wolf, elk, reindeer, musk-deer, mountain sheep, and others, but also those burrowing in holes and dens, like bears, otters, foxes, marmots, spermophiles, mice, lemmings. According to the reports of hunters, some of the animals which ordinarily live in dens build their nests in hollow trees, because of the swampiness of the upper strata of the ground. 134

Of greater interest is the important rôle this frozen soil plays in the conservation of the remains of the extinct mammoth and rhinoceros. These are found, not in the ice itself, but in the earth above it. The mammoth belongs to the post-Tertiary or Pleistocene epoch and was contemporaneous with man. Its remains were found in central Europe, northern Asia, and the northern part of the American continent; the still extant rhinoceros is no longer found in Europe and North Asia. In America it became extinct before the end of the Pliocene period.

The underground ice of Alaska and northern North America, in general, has been described by many American explorers. One of the latest is Vilhjalmur Stefansson. However, nowhere in America are ice beds known to extend as far to the south as they do in northern Asia.

The Tundra

The usual conception of the whole northern region as a swampy tundra sloping down to the Arctic Coast is not quite correct. Northern Siberia includes several mountain ranges which in many places extend to the Arctic Coast and continue on to the islands in the Arctic Ocean. The greatest extent of tundra-like plains is found in the valleys of the middle and lower courses of the great rivers and their tributaries. The largest swampy tundras are found between the Kolyma and Alaseya rivers and in the valley of the Indighirka River. These areas are studded with many lakes, large and small, connected with one another or with the great rivers by small streams. Since the underground glaciers thaw out late in the season in summer, these swampy tundras constitute a greater barrier to communication than the mountain ranges. Consequently, the Yakut saddle and pack horses, as well as the Tungus riding reindeer, sink into the swamps up to their bodies. As might be expected, under such conditions, long journeys or nomadic camps are very rare in the summer. 133

The natives call treeless places on hills or mountain slopes "dry" or "stony" tundras. Many of these dry tundras skirt the swampy areas and thus afford passable detours as substitutes for the shorter routes through the almost impenetrable swamps.

2: Jochelson E-5 (1884-1902) 1933 Yakut

intensity of the cold, with temperatures which may drop to –65 degrees. Precipitation generally occurs in the first half of winter. The greatest depth of snowfall averages from 30 to 40 cm., and occasionally may be 70 to 80 cm. /32

Spring is short, begins late (in the middle of April), and may be characterized by sharp variations in temperature. The precipitation during April and May is greater than in the winter months, but is, nevertheless, negligible.

The most characteristic features of the Yakut summer are: continuous sunshine (up to twenty hours daily); very few clouds; a high degree of sultriness in the middle of the day (up to 39 degrees in the shade) and a considerable fall in temperature during the short night; the period without frost lasts from 115 to 120 days; considerable dryness of the air and slight rainfall, about 30 to 40 mm. per month.

Autumn, like the spring, is very short, lasting but two months (September and October); the range in the variation of temperature is very large and the curve of average diurnal temperature falls sharply in October; precipitation is greatly reduced, as compared with that in summer.

The mean annual temperature varies at different points from –6.8 degrees to –10.7 degrees; the mean temperature of January from –35.5. to –44.8 degrees, of July from 18.3 degrees to 19.4 degrees, that of the three summer months being 16.5 degrees.

The mean annual precipitation for a number of years for various localities ranges from 187 to 271 mm. During the five warm months (May to September) the rainfall is from 130 to 192 mm.

Comparative data show that with respect to the quantity and distribution of precipitation, as well as the temperature of the summer months, the Lena-Viliui plain differs but little from the steppe regions of central Siberia (Chita, Irkutsk, Minusinsk and others) situated much further south. This peculiarity of the climate of the central Yakut country should be particularly borne in mind, as an exaggerated importance has generally been attributed to the severe winter frost. Beyond its purely practical importance for the needs of agriculture, this climatic peculiarity affords a clue to the comprehension of many phenomena in the flora and soil of the country which do not otherwise seem in accord with the usual conception of a territory lying between 62 and 64 degrees north latitude. The duration of t e period of warm weather and of the intensity of the summer heat in the region of the Lena-Viliui plain is sufficient to ensure not only the development of a very diversified natural vegetation, but also to render possible the successful growth of cultivated plants having a fairly long period of vegetation. /34 /37 /32 [241]

2: Jochelson E-5 (1884-1902) 1933 Yakut

natural vegetation, but also to render possible the successful growth of cultivated plants having a fairly long period of vegetation.

As a consequence of the continuous extreme winter cold should be noted the universal prevalence through the Lena-Viliui plain of the permanent frozen earth-layer (*merzlota*). The depth to which the soil thaws out varies with the conditions of exposure of the slope, the thickness of the humus stratum of the soil, the character of the humus, the petrographical composition of the soil and the degree of moisture. Likewise of great importance is the composition and character of the vegetation, the meteorological conditions, and the depth of the snow in winter. In 1912 was observed a maximum thaw to a depth of 225 cm. in dry sandy soils under thin pine growth. Dry humus soils thawed out under short grass meadows and meadow-steppes to the depth of 200 cm. Humus and humus-peat soils of moist meadows thawed to a depth of 120–150 cm. In larch forests the permanently frozen layer was encountered at a depth of 75 to 125 cm., the variation being due either to the absence or presence of a moss covering. The soil of swampy peat bogs was always found to be permanently frozen at a depth of 25 to 30 cm. below the surface.

A permanent frozen earth layer has never been found under water. The ice crust formed on the surface of the water is so poor a conductor of heat that it presents an insurmountable barrier to the penetration of low winter temperatures into the depths of the water.

The presence of a permanently frozen substratum must be regarded as a positive agency in conditioning the climate of the Yakut country. In view of the small amount of summer precipitation, toward the close of summer, the entire layer of thawed out soil is very considerably dried up. Such desiccated soil greedily absorbs all the autumn rains. Subsequent frosts rapidly transform all this water supply into crystals of ice, distributed among the particles of the soil. In spring the mantle of snow thaws while the soil remains completely frozen. Owing to the flat surface of the plain the superficial drainage is insignificant, and all the spring water remains *in situ*, and does not percolate through the deeper layers of the soil. During the gradual thawing out of the soil the snow is partly dissipated by evaporation and partly penetrates the soil by following the receding impervious frozen pan. As the upper strata of soil dry, the water collected underneath rises by means of capillary action, and forms a reliable source of moisture for the normal development of vegetation. When this supply is consumed, it is replaced by the last stores of water, which had frozen the preceding autumn in

2; Jochelson E-5 (1884-1902) 1933 Yakut

the deeper strata of the soil, and which become available as the ice thaws. 134 137

Thus, the permanent frozen earth-layer presents a most beneficial means for the conservation and very economical consumption of water, without which the whole extent of the Lena-Viliui plain with its 200 mm. of annual precipitation and its 19 degrees of mean July temperature would be converted into an arid desert, incapable of cultivation and entirely devoid of forest. 132

28: Grigoriev-171-172 N-5 (1925) 1926 Yakut-1-2
116, 121, 134

"The country visited may be divided into two regions: the plateau on the south, and the mountain chain on the north. A short account of the geology and geomorphology of each will be followed by a description of the soil covering of the whole country visited, both being the results of the investigations carried out by professor A.A. Grigoriev and his assistants in the summer of 1925."

1. Aldan plateau

Beginning with the geology and the geomorphology of the Lena-Aldan plateau it should be mentioned that the plateau owes its name to the river Lena and its largest right tributary the Aldan, and occupies the area limited on the west by the former and on the east and north by the latter The object of the party was to investigate the north western part of this plateau, which has been more than once visited by explorers. They have, however, left but very scanty records of their observations in this country beyond general statements upon the land surface consisting of Quaternary sediments and presenting a very uneven configuration. Such a paucity of records of former investigators is largely due to their having all rapidly traversed the region, in most cases during the winter or early spring, while the ground was still covered with snow and they could travel more expeditiously and comfortably in sledges. [172]

28: Grigoriev--171-172 N-5 (1925) 1926 Yakut-2
116, 121, 134

The author (prof. A. A. Grigoriev) succeeded in traversing the Lena-Aldan plateau in the following directions: 1) from Uly-Ary (on the Lena 40 klm below Yakutsk) to the NNE as far as the Dygdala left shore of the Aldan (opposite the mouth of its tributary the Kel (a distance of 185 klm); 2) from the Aldan, somewhat west of the mouth of the Kel to the N as far as the Tumara (a distance of about 60 klm); 3) from the Dygdala shore to the East as far as the mouth of the Tanda, and 4) from the village of Tanda along the so called old Verkhoyansk post road to the S and SW on the way back to the village of Yarmonka, situated on the right shore of the Lena, opposite Yakutsk."

28: Grigoriev--172-176 N-5 (1925) 1926 Yakut -1-7
116, 134

"In summarising all the information collected by the members of the expedition in the course of their field investigations on the plateau, the following sketch of the leading characters of its geology and relief, as far as it alludes to the north western part visited, may be presented.

The plateau is exclusively formed of loose sediments. They overlie a stratified sheet of gravel and coarse sand, disposed in regular layers or in lenticular shape, usually of a rusty red hue due to the presence of iron oxides.

The pebbles of this suite are composed of various sandstones, granite, light yellow quartzite, porphyry tuff, hornblende andesite, other andesites, quartz hornstone, contact hornstone--all rocks which are not encountered in the adjoining parts of the Verkhoyansk mountain Range, and for the origin of which partly the Stanovoy Mountain chain or possibly the crystalline mass of the region of the upper Aldan must be sought for. The arenaceous horizons of this series often exhibit a very well expressed cross bedding. This series in general presents a very great similarity with Upper-Jurassic conglomerates and sandstones, exposed on the surface of the Lena-Aldan plateau somewhat to the south of the latitude of Yakutsk, where their superficial horizons not infrequently appear also to be of a loose texture. On the other hand, they very much resemble the Upper-Jurassic conglomerates of the Viluisk basin which, according to the researches of V.N. Zverev and A.G. Rzonsnitski, (1) represent a gold bearing formation and are

1. See Izv. Geolog. Com Vol. XXXVI. 1917.

sometimes described as being 'loose con-[173] glomerates.' It is much to be regretted, that a lack of suitable apparatus prevented the author of this volume from throwing more light on the gold bearing capacity of these deposits in the region under discussion, but there is in any case much probability that they are of Upper-Jurassic age. These strata are exposed in sections on the Aldan, both opposite the Dygdala shore, and near the mouth of the Tanda, as also in the low lying ground bordering the latter. They are likewise exposed 40 klm south of Dupsun. They may thus be regarded as being widely distributed over the whole region, although in view of the absence of deep sections rarely disclosed. They underlie layers of dark grey sand interpolated with clays of the same colour; here, in the lower horizons at least, are present intercalations of half decayed plants, which are always found deposited upon sand and covered with clay. As determined by V.N. Sukachev these remains belong to a stage not earlier than the Interglacial, more probably to the Preglacial, with a climate similar to that of the present day. To the NE of the region visited this series is not remarkable for thickness, as the major upper part of it is replaced by thick layers of very coarse gravel, which may be characterised as exhibiting an exclusive prevalence of sedimental rocks of the Verkhoyansk type. These beds of gravel are well developed on the Aldan, both opposite the Dygdala shore, as well as somewhat further north on the Tumara. Their thickness increases towards the N, as may be seen by their being under 8,5 m on the Aldan, while, without taking account

of the layers which are buried below the water level, exceeding 15-17 m on the Tumara. In the region of the Tanda they are replaced by an argillaceous sandy formation of a thickness of up to 25 m (it being only 2, 3 m thick in the Dygdala region), the clays in its upper horizons becoming slightly carbonaceous and assuming a brown colour. These deposits extend far to the south, and their upper horizons become exposed on the right shore of the Lena somewhat below the latitude of Yakutsk (10 klm below Yarmonka); they have also been observed on the lower reaches of the Tanda.

The stratified series just described, as well as the thick gravel layer which supplants it, underlies, the first on the E and SE, the second on the NW, a thick sheet of unstratified loam generally carbonaceous, with local inclusions of vast boulders of fossil ice, which reach a thickness of 25-30 m, the loams possess-[174]ing a still greater thickness. Towards the west the loams are replaced by unstratified sands.

The above mentioned boulders of ice are of a granular structure, filled with air vesicles, and devoid of any stratification. Externally they fully resemble the fossil ice of the more northerly tracts of the Lena basin, usually regarded as firn ice and formed of extensive motionless accumulations of snow of the Glacial age. The bones of the mammoth occurring in the region described, as well as in more northerly districts, are generally found in the exposed strata con- ining these boulders of ice. It is remarkable that these boulders of fossil ice are usually deposited in the more elevated parts of the present relief. On the extreme NW of the region under consideration (on the Tumara)

the loams that envelope the ice lose their carbonaceous character and are represented in two varieties: the upper sheet (1, 5 m)without traces of stratification, and the lower, in immediate contact with the ice, in which thin (3-5 mm) intercalations of loam are interposed with yet thinner seams of ice. This second variety is most abundantly developed in the spaces intervening between the boulders of ice, i.e. in the fissures of firn ice, which have been subsequently filled with sediments deposited by waters caused by melting ice and snow.

In all other cases the loams (carbonaceous) exhibited no stratification, and if such in rare cases was present it was never disposed horizontally. Sands, which replace the loams on the west (in the Lena zone), attain a thickness of 40 m on the banks of the Lena, where they are of a greyish yellowish colour, gradually becoming grey further east. These sands dip under the loams in the E and gradually wedge out. That such is the case may be inferred from the country rock banks of the ancient Lena valley being almost exclusively formed of these sands, whereas the sands overlying the loams on the Aldan opposite the Dygdala shore are but 9 m thick and completely disappear from sections at the mouth of the Tanda.

While between Uly-Ary on the Lena and Dygdala the sands rapidly disappear under loams, further south on the Verkhoyansk post road the case becomes more complicated:

along the route from E to W wide bands of carbonaceous loam alternate with narrow sandy ridges until further W on approaching the Lena the sands become the dominating rock. [175] Throughout the route the sands may not unfrequently be observed to be superimposed by sheets of loam. Yet the height of the ridges, however composed, undergoes little change. Whence follows the obvious conclusion that the sands exhibit a markedly undulated surface. It should also be observed that both in the region of the exclusive prevalence of sands, and also in spots where they emerge but as solitary ridges, occasionally in depressions and on flat areas, the sand is covered by a thin layer of carbonaceous loam, several decimetres thick, reposing on a similar layer of slightly carbonaceous sandy loam; or the two latter layers may be represented by the sandy loam alone.

The above indicates that a continuous loam mantle which was removed by denudation was here formerly present.

The sediments described above and deposited on top of Upper-Jurassic loose conglomerates (gravel and sand) appear to be of Quaternary age, while the lower horizons of the sandy-argillaceous suite with intercalations of plant remains should be relegated to the Preglacial age, the intermediate strata to that of the Primary glaciation, and the top layers (with interpolations of brown carbonaceous loams) to the Interglacial epoch. The upper gravel beds, replacing the intermediate and upper horizons of the argillaceous sands, should be assigned to the Interglacial, and also very probably to the Primary Glacial epochs. To these same Interglacial deposits probably belong the sands bordering

on the Lena, which replace the upper gravel horizon on the west, whereas the fossil ice with its enveloping mantle of carbonaceous loam, as well as the carbonaceous loams and clays in general are of the most recent Glacial age.

The gradual substitution of the sandy clay horizons by the gravels of Verkhoyansk origin on the N is most probably connected with the erosion of the moraines of the Primary glaciation, which has culminated in the production of boulders.

The development of the stratum towards the NW seems to indicate that the Verkhoyansk mountain glaciers, owing to the discontinuous character of the Verkhoyansk mountain Range had here a freer access to the S, whereas in the eastern direction, where the Yakut mountain Chain separates the Verkhoyansk uplands from the Aldan plateau by a continuous barrier, that Chain offered a very serious obstacle to the motion of the glaciers, beeing at the same time too steep and narrow to afford [176] the necessary conditions for an extensive development of its own system of the latter. Thus, the glaciers of the Verkhoyansk mountain chain have amassed their terminal moraines at a greater distance from the Chain in the western, than in the eastern direction, as is exemplified in the region of the Tukulan.

The country in the Interglacial age, and most probably in that of the First glaciation, as also in the time immediately preceeding it, represented on the whole an extensive lake basin, on the bottom of which was deposited the series of sediments described above. The

presence in the upper layers of this stratified series of carbonaceous clays interpolated with sand indicates a notable shallowing of the basin prior to the arrival of the last Glacial epoch."

III. Soils of the Lena-Aldan plateau and Verkhoyansk mountain regions.

In summing up all the observations made on the soil mantle of the regions under discussion the following conclusions have been arrived at:

1. In respect of soils the Lena-Aldan plateau visited by the author may be divided into two parts: one, the western, bordering on the Lena, which may be characterized as having a predominating sandy subsoil, and the other, the eastern part, with an all but exclusive development of carbonate loess-like loams; both soils do not thaw out to a greater depth than 40-120 cm from the surface.

2. Dark coloured (humous) carbonate bearing soils (carbonate alkaline soils of K.D. Glinka), not infrequently leached out in various degrees at the surface, are typical of the carbonatic loams (both in the region of their continuous, as also sporadic, occurrence in [195] the arenaceous zone) of the flat elements of the relief and of the sloping margins of valleys and lakes.

3. The depth at which the soil effervesces with acid (height of effervescence) in the above mentioned carbonatic soils is affected by: a) the relief, b) the position of the locality in regard to the neighbouring mountainous tracts, and c) the depth of the deposition of the permanent ice layer.

4. The depth at which commences the effervescence of carbonatic soils on the flat elements of the relief increases with the proximity of the locality to the Verkhoyansk

Range, gradually descending from the horizon A of the soil (upper) to the horizon B (intermediate) and, finally, falling to that of C (lower) and thus sinking to a depth of about 40 cm from the surface. This progression in the depth of effervescence is explained by the increasing humidity of the climate, as the Range, which may be regarded as the principal local condenser of moisture, is approached.

5. The dependence of the height of effervescence of carbonatic soils upon the relief is chiefly exemplified in the carbonatic horizon ascending to its greatest height at the immediate base of the high banks of valleys and of closed depressions without outlet, whereas on the adjacent heights and in the deeper parts of depressions effervescence commences lower down: the former circumstance may be accounted for by the accumulation at the base of the old shore lines of carbonate soil waters descending down the declivities, where they are subject to an increased evaporation.

6. The connection between the depth of the effervescing horizon with that of the permanent ice layer is exhibited in the effervescence commencing nearer to the surface when the permanent ice layer, and consequently the soil waters, are disposed at a greater depth; such has at least been observed to be the case in regard to more or less flat surfaces, all the other conditions being equal.

7. On steep declivities the relations indicated in paragraphs 5 and 6 are modified: under the influence of the percolation of the soil moisture the effervescence may

commence very close to the surface on declivities, although the permanent ice layer may be at a low depth from the surface; in such cases, however, [196] the contents of lime in the superior horizons of the soil is relatively small.

8. In the regions of the distribution of carbonatic loams the alluvial soils of perennial streams do not usually contain carbonates, while those of temporary water-courses (disappearing in summer) effervesce at a certain depth.

9. Soils of depressions, occurring chiefly in the proximity of lake banks, and having outlets in spring only, or none at all, are composed of carbonate alkalis, between which and the decomposed carbonatic soils of the interfluviatile tracts there seems to be a series of transitions. They are met with both in the south, and in the north.

10. The wide distribution over the flat elements of the relief under forest of carbonatic loams leached out from the surface especially towards the north, the soil sections exhibiting certain features characteristic of podzolization, affords grounds for assuming that the processes of degradation of these soils are relatively recent and the present epoch was preceded by one with a drier climate.

11. The recency of the process of leaching is indicated by the soils of the Lena arenaceous zone being deposited upon thin (often but 20-25 cm thick) superficial layers of loams and sandy loams underlaid by sand. In an overwhelming majority of cases, at least in the central and southern parts of the region, such soils effervesce at a certain depth, not infrequently beginning with the surface, notwithstanding the presence

of conditions very much favouring leaching. In the immediate proximity of the Aldan R. alone the argillaceous covering is under similar conditions entirely devoid of carbonates.

12. Occasionally, and chiefly in the Aldan region, the horizon B of the humous carbonatic soils has a reddish hue, which is typical of humous soils on loess.

13. The arenaceous soils of the north-western part of the Lena-Aldan plateau on flat patches of the relief and on declivities are devoid of carbonates elements and possess the character of typical 'podzol' soils.

14. The intensity of the process involved in podzolization on sands is dependent upon the relief and the depth of the permanent ice layer. The relation of this process to geographical posi-[197] tion has remained undetermined, its intensity on the north differring [sic] but slightly from that on the south.

15. The relations indicated above show that the strongly 'podzolized' soils with a thicker horizon A_2 (being the third sublayer of A counting from the surface) usually occur on softly sloping declivities and not on flat elements of the relief; on these latter the manifestation of the podzolizing process is relatively slight; at the same time a more intense process may be universally observed to ccour on areas, where the permanent ice layer is not far from the surface, in other words, where the level of the ground

waters is higher; finally, the thickness of the horizons A+B in many cases, is relatively very small (10-20 cm). The above indicates relatively unfavourable climatic conditions consisting above all in the amount of precipitation being inadequate towards the full development of the podzolizing process.

16. Both at the bottom, as well as on the inferior parts of the declivities of the closed depressions of the arenaceous region are widely spread highly alkaline soils (carbonate alkalis) effervescing at the very surface and sometimes containing grains of concretions of calcareous salts.

17. On the north, within the limits of forest growth in the region of the distribution of the terminal moraines of the Verkhoyansk glaciers and higher up the mountains, podzolized and marshy soils, usually very shallow and gravelly, are alone developed.

18. The character of these soils in the mountainous region depends upon the incidences of the relief and the degree of exposure of the declivity: on well drained elements of the relief exposed to the action of the sun's rays, the podzol soils, although not free from being slightly swamped, ascend to the very limits of tree growth; in the absence of such conditions, 'glei' bog soils or peat 'glei' bog (1) soils predominate, while in the shaded

1. Reduced clay and loam soils at a certain depth from the surface subject to constant moisture.

portions of steep valley declivities, along which the rain waters descend through coarse gravel, the soil is often totally wanting, being replaced by ice, deposited directly beneath a superficial growth of mosses and lichens. [198]

19. The genesis of the soils of the north western part of the Lena-Aldan plateau may be outlined as follows:

The disappearance of the Verkhoyansk glaciers and the initial stages of the gradual extinction of fossil firn ice in the region of the plateau were connected (1) with the

1. Brückner holds that in the Glacial age the summer in Siberia was 4-5° colder than it is at present, but the winter was correspondingly warmer. G. Brückner. Bemerkungen zu der Abhandlung des Herrn Lamansky über das Absterben der Gletscher. Zeitschrift für Gletscherkunde. Bd. VIII. H. 4. 1914. P. 195.

substitution of the relatively equable climate of the Glacial Period with its very cool summer by a climate still more continental than the present. Such a climate offered favourable conditions for the retention of salts in the soil and for the dispersion of herbaceous growth of a steppe type, both circumstances contributing to the development of dark coloured humous carbonatic soils, not infrequently approaching 'tchernoziom'

in certain features, which were deficient only on sands, and that not invariably. The climate subsequently evolved in the direction of an increase in summer precipitation and had a tendency towards softening the extremes of that season of the year. This modification of the climate was accompanied by the substitution of forest (taiga) for the steppe, which beneficial change could only be accomplished thanks to the larch, the least exacting of all Siberian trees. No other trees, with the exception of relatively small detached areas, meet as yet with suitable enough conditions for their growth. In the mountains only the birch may be pretty widely spread along with the larch, as is the pine on sands, where it even predominates. Such a conquest of the steppe by the forest naturally commenced in the mountain ranges surrounding the plateaus, where trees could take root so long ago as during the preeminently dry Post-Glacial period, subsequent changes in the climatic conditions first beginning to be felt at the base of the mountains. Under the influence of the gradual change in the climate and the altered vegetation the humous carbonatic soils became modified, and commencing with the superficial horizon began under the process of leaching to obtain certain features characteristic of podzol. Still, even in a relatively close proximity to the Verkhoyansk Range the changes in the climatic conditions were not powerful enough to radically affect the soils of completely or half closed depressions [199] highly charged with alkaline salts, which have apparently subsisted without considerable alterations. and into which, with the only exception of the region of non-carbonatic Lena sands, the forest has not

penetrated.

Such a sequence in the course of the changes to which the region was subject seems to account satisfactorily for the occurrence on the Aldan plateau of a series of steppe plant forms, as also of certain steppe animals, such as the 'ovrazhek' (suslik) met with by the author likewise in the Yana valley; these forms represent the surviving remnants of other conditions, which, as has been shown above, have not, however, changed so radically, as to have caused the complete extinction of the hardier aborigenes of the former steppes.

Here, as in other districts of Eurasia and in North America the general causes which had contributed to the softening of the extremes of the continental climate of the preceding epoch, could not have failed to act, the forest vegetation of the northern parts of Eurasia and in particular that of the countries bordering on the lower Yenisei, (1) having,

1. See Kuznetsov, N. J. Vegetation of the Yenisei tundra. Preliminary report of a botanical investigation of Siberia and Turkestan in 1914. Petrograd 1916, p. 28.

Grigoriev, A. A. The arctic boundaries of the forest growth in the Bolshezemelskaya and some other tundras. Zemlevedenie. Vol. XXVI, 1924, p. 86.

Lopatin. Journal of the Turukhansk expedition. 1866. Zap. Ross. Geogr. Obshch. po Obshch. Geogr. Vol. XXVIII, p. 2, 1897, p. 19.

under their influence, in comparison with the present epoch, extended not less than 150-200 klm further south. A certain importance, on the other hand, judging from the shape of the valleys, may be attributed to the probably recent sinking of the Verkhoyansk and Stanovoi Ranges, as also to the continuous subsidence of these mountains due to processes of denudation, in consequence of which the moist winds blowing in summer from the Ocean carried with them a somewhat greater quantity of precipitation than formerly."

/175 cont./

137 The timber line now passed by us lies at 71 1/2° latitude. It is not fixed very precisely, for individual streaks of forest extend tonguelike into the tundra, and here and there one finds smaller or larger islands of forest, so that here the transition from forest to tundra, in contrast to what we saw earlier, was a very gradual one. Lone before our last camp it was noticed that the forest was becoming steadily poorer and more stunted, and from there the signs
122 of its imminent cessation multiplied. On the next day we crossed the watershed between the Pur and the Boljkalák, the last large tributary of the Olenék. Since it was no longer snowing we advanced quite rapidly, but when it became dark we had still not reached by far our camping place designated for tonight by the guide, but rather only a very small hut in the middle of the tundra, which we used to revive ourselves somewhat. Then we continued our journey in the darkness and finally reached a small, but cozily warm balagan on the little river Molokó, which empties into the Boljkalák. On the next day we followed the course of this little river and then the Boljkalák itself, but our /176/ guide, in shortening the route by cutting off the bends, multiplied its difficulties and in crossing the steep sides of the bank our narten, and we with them, frequently took a fall. Otherwise Czekanowsky
[133] was very satisfied. The rocks here decidedly no longer belonged
• [134] to the Silurian formation which had become so very boring to us, for coal appeared, but unfortunately no petrifactions.

122 In the evening--it was October 20, that is, exactly four
123 months since we had reached the river system of the Olenék at
621 the Ljútscha Ongókton -- we found ourselves at the goal of our long journey, at the little village of Boljkalák lying at the mouth of the Boljkalák into the Olenék, officially Ustj-Olénskoje, i.e., mouth village of the Olenék, and stopped in front of the stately balagan of the local elder, which had been assigned to us for a
[574] dwelling. Informed previously about our imminent arrival, the entire male population -- it was an imposing crowd; we at least had not seen so many people together for a long time, but in all only seven families are said to live here -- stood ready to welcome us and greeted us with low bows as we climbed out, while upon entering the balagan we were received by the ladies of the house.